Diagnosing cardiac disease states using a minimal cardiovascular model

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AIMS: Cardiovascular disease states are difficult to diagnose due to a variety of underlying dysfunctions combined with reflex mechanisms. To provide more consistent care a cardiovascular system model is combined with an efficient patient-specific parameter identification method. The goal is to identify the patient's condition and to predict the future patient-specific reaction, making this approach a potential means for model-based guided therapy.

METHODS: The model and parameter-identification method are validated using clinical haemodynamic data measured during drug induced porcine pulmonary embolism experiments (N=6) and PEEP titration experiments (N=6). Identified model parameters are correlated to create predictive measures of haemodynamic changes to clinical therapy or patient condition. Prediction is tested for observed changes in arterial pressure (AP), pulmonary arterial pressure (PAP) and stroke volume (SV) as caused by a clinical change in PEEP.

RESULTS: The parameter-identification method tracked pulmonary embolism in porcine data from an initial healthy to the disease state. The full range of hemodynamic responses was captured with mean errors of 4.1% in the pressures and 3.1% in the volumes. Pulmonary resistance increased significantly with the onset of embolism, as expected, with the percentage increase ranging from 89.98% to 261.44% of the initial state. Changes in AP, PAP and SV due to an increase in PEEP were predicted with a mean absolute percentage error less than 10% for 6 data sets.

CONCLUSIONS: These results provide a first clinical validation of this model-based diagnostic therapeutic decision support approach to haemodynamic management.